Simulations of the Discovery of Centaurs and Kuiper Belt Objects

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We have performed Monte Carlo simulations of the discovery of Centaurs and Kuiper Belt objects (KBO's) in ecliptic surveys. Our goal is to constrain the populations of these objects and their distributions of size and distance from the Sun. In particular, we apply our model to the new Mauna Kea survey by Jewitt *et al.* (*Astron J.*, in press, Sep. 1996), which discovered 12 KBO's and 2 Centaurs (1994 TA and 1995 DW_2). Because Centaurs typically survive only a few Myr before being ejected from the solar system by one of the giant planets, their numbers should be small compared with the number of KBO's; thus discovery of even one Centaur in a pencil-beam survey is surprising if Centaurs originate from the Kuiper Belt (cf. Irwin *et al.*, *Astron J.* **110**, 3082, 1995). We assume the following: (1) The Kuiper Belt has two components: non-resonant objects with semi-major axes $a > 42$ AU, and objects in the 2:3 resonance at $a = 39$ AU and (possibly) in the 1:2 resonance at $a = 48$ AU (Malhotra, *Astron J.* **110**, 420, 1995). (2) The number of Centaurs increases with distance from the Sun, r, for 10 AU $\leq r \leq$ 30 AU, based upon orbital integrations by Levison and Duncan (preprint, 1996). (3) The distribution of diameters is a power law, with differential index q, and an upper cutoff. If we assume $q \sim 3$, the ratio of the observed number of Centaurs to Kuiper Belt objects exceeds the model's predictions by a factor of 10–100. (The large range primarily reflects the small number statistics of the Centaur discoveries.) If we use the steeper size distribution assumed by Weissman and Levison (in *Pluto-Charon*, U. Arizona Press, 1996), which has $q = 4.5$ at large sizes, our model is marginally consistent with the number of objects discovered by Jewitt *et al.* However, if the size distribution were really this steep, the discovered objects would typically be smaller and closer than 1994 TA and 1995 DW_2. On this basis, all models with $q \geq 4$ can be rejected at the 95% confidence level, even allowing for generous uncertainties in the limiting magnitude of the survey and the spatial distribution of the Centaurs. We will present the implications of these results for the origin of the Centaurs.

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